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Barriers and Opportunities to Electric Vehicle Development in Nepal

Allyson Krupa
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Barriers and Opportunities to Electric Vehicle Development in Nepal

Allyson Krupa

SIT Study Abroad Fall 2019

Denison University

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Abstract

As the global carbon dioxide level reaches its highest point in human history (407.4 parts per million)¹, energy systems must transition from fossil fuel to renewable-powered sources. Since the transportation sector contributes nearly one-third of global greenhouse gas (GHG) emissions, electric mobility offers a significant opportunity to reduce GHG emissions. Globally, there has been a rise in demand for electric vehicles. In Nepal, a clean energy transition within the context of rising urbanization and air pollution is imperative for quality of life, socio-economic development, and broadly climate change mitigation/adaptation. Furthermore, Nepal's vast hydropower potential may increase energy independence and provide a cleaner alternative to fossil fuels. Unfortunately, infrastructure is not currently suited for fossil fuel alternatives. Thus, this paper uses a case study to explore the barriers and opportunities for electric vehicle development in Nepal. Methods include document analysis, social media analysis, and interviews with different stakeholders. My discussion centers around stakeholder perspectives and consumer perceptions to find themes and trends of electric mobility in Kathmandu. In reference to these findings, I suggest recommendations to increase EV adoption.

Introduction

As the global carbon dioxide level reaches its highest point in human history (415 parts per million)², reducing greenhouse gas emissions becomes increasingly urgent for countries around the world. Since it is generally accepted that greenhouse gas emissions (GHG), like carbon dioxide, contribute to global warming, energy systems must transition from fossil fuel to renewable-powered sources. A significant sector to target is transportation, which contributes nearly one-third of global greenhouse gas emissions. Electric mobility is a popular alternative because it does not require petroleum products. Different types of electric vehicles include hybrid electric vehicles (HEV) and plug-ins. HEVs have both a battery and internal combustion engine and can recharge during braking to increase fuel efficiency. Plug-ins are powered only by a battery and plug into an outlet to charge.³ Electric vehicles are more flexible than internal combustion engines because they decrease dependency on oil, and electricity can be derived from different energy sources, such as wind, solar, or hydropower.⁴ This technology can thus provide transportation that sources from renewables, which benefits the environment and diversifies energy security.

Additionally, electric mobility reduces air pollution, which causes 7 million global deaths annually and is linked with 6.5 million premature deaths around the world.⁵ The World Health Organization (WHO) defines air pollution as “contamination of the indoor or outdoor environment by any chemical, physical, or biological agent that modifies the natural characteristics of the atmosphere,” and contains airborne Particulate Matter (PM) and gaseous pollutants that are emitted by ICE motor vehicles.⁶ This is a problem for dense urban populations with many ICE vehicles on the roads. Figure 1 and Figure 2 below demonstrate increasing emissions caused by the energy sector and combustion engines. They show the urgency of the

situation because GHG has been steadily rising and the transport sector has been taking up a larger share of GHG.

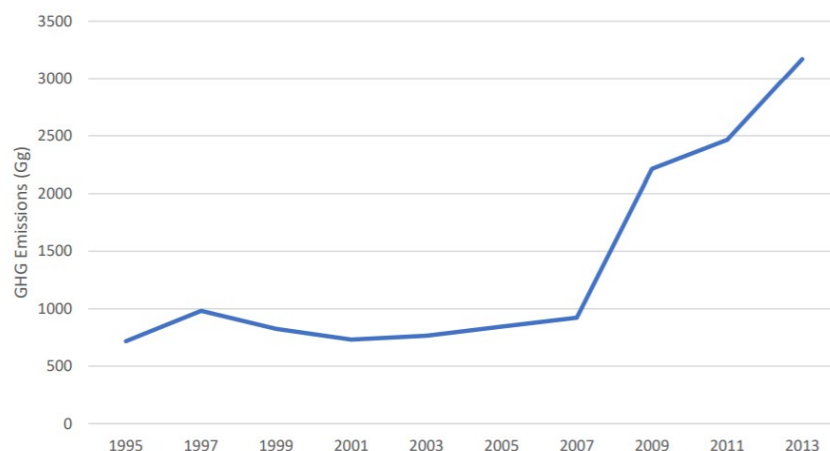


Figure 4.5. Trend in transport sector greenhouse gas emissions during 1995-2013.

Source: World Bank, 2017³⁵

Figure 1. Source adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

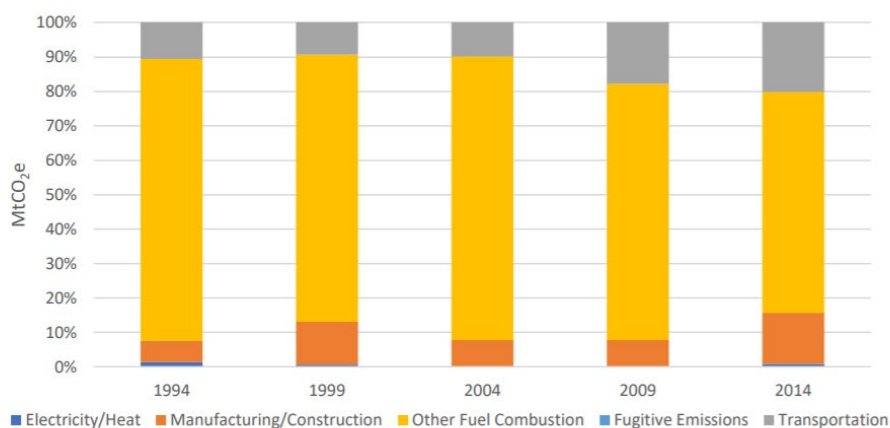


Figure 4.4. Emissions from energy* sub-sectors during 1994-2014

Source: WRI, 2017.

Figure 2. Source adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

Unfortunately, Nepal has rising urbanization, dominance of ICE vehicles, and poor air quality. Its current population is around 30 million, which may grow to 60 million by 2040 with increasing migration to urban areas.⁷ In parallel, the number of motor vehicles is increasing, as demonstrated by the growth in registered vehicles in Figure 3:⁸

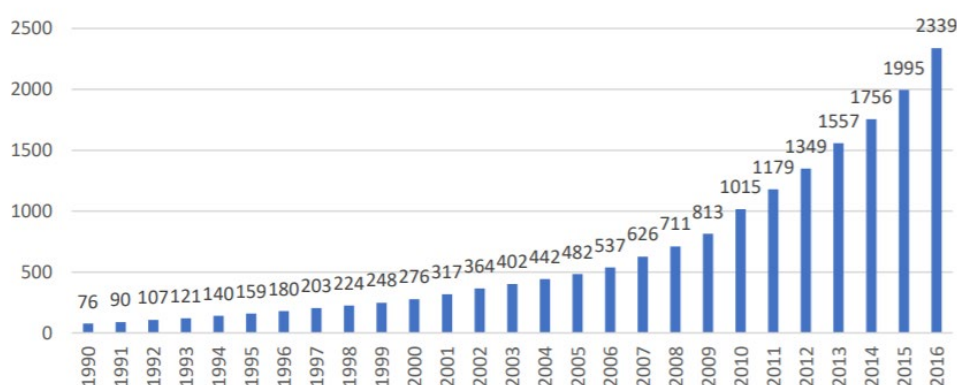


Figure 3.1. Total registered vehicles in Nepal (thousand)

Source: United Nations Centre for Regional Development, 2015

Figure 3. Source adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

The topography of the Kathmandu Valley, which is home to the largest city in Nepal, is exceptionally shaped to trap vehicle emissions. The valley is surrounded by mountains from 2000-2800 meters above sea level, giving a bowl-shaped topography. This limits the movement of wind, so air pollutants are confined to the valley area. Combine rising population, urban development, and motor vehicles with this bowl-shaped topography, and air pollution becomes a major issue. For example, fine particulate matter (PM) has nearly doubled in the past three decades in Kathmandu. It has become 4 times higher compared to low-income countries and 3.5 times higher compared to lower middle-income countries. Furthermore, the average exposure of

PM2.5 in 2016 was five times higher than the WHO standard.⁹ Consequently, 35,000 people die each year from poor air quality in Nepal, and areas with the worst air quality, such as Kathmandu and Chitwan, have lower life expectancy by at least four years.¹⁰ Figure 4 demonstrates the Air Quality Index (AQI) from April 1, 2018 to May 1, 2019, of which the majority is at an unhealthy air quality. AQI of 100 (orange), air is deemed unhealthy for sensitive groups, and air quality worsens as the number rises. For instance, AQI above 300 (maroon) is deemed hazardous.¹¹

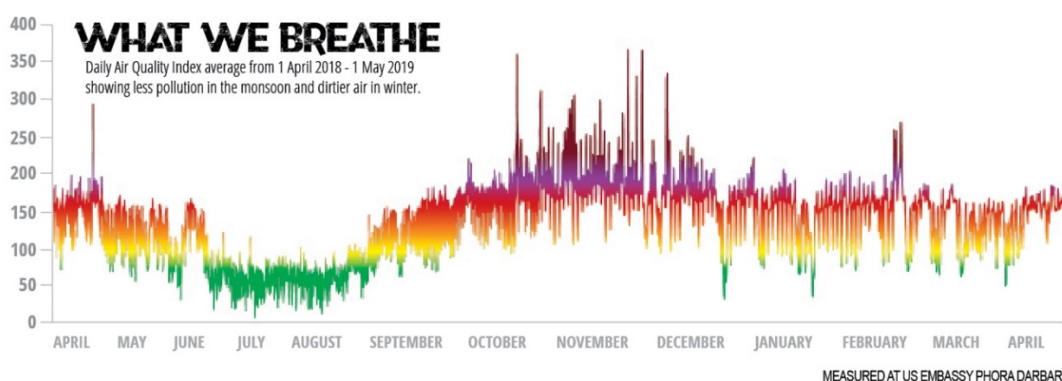


Figure 4. Source adapted from: (Awale, S. May 31, 2019. “Air pollution is more dangerous than smoking.” *Nepali Times*. <https://www.nepalitimes.com/here-now/air-pollution-is-more-dangerous-than-smoking/>.)

There is even an economic cost due to the detrimental effect of air pollution on human health—South Asia loses more than \$66 billion yearly, contributing the most to an annual global loss of \$225 billion.¹²

The Power of Hydroelectricity in Nepal

Fortunately, Nepal has extraordinary potential for electric mobility due to stable electricity from hydropower. Approximately 70 percent of Nepal’s population has access to grid electricity.¹³ This follows severe power shortage from 2006-2016, when load shedding was required at times up to 18 hours a day.¹⁴ Only after energy imports from India did relief come from electricity shortage. However, Nepal is developing its own for energy stability through

hydropower projects. With power demand expected to double by 2025, these projects are critical for securing economic, environmental, and social development.¹⁵

Nepal is estimated to have hydro potential of 83,000 MW but currently has generation capacity at a mere 1,047 MW.¹⁶ The government aims to increase this number by reaching 15,000 MW hydroelectricity by 2029. However, there are numerous hurdles that delay constructing adequate energy infrastructure. These obstacles include lack of hydrological data, bureaucracy, acquiring foreign and private investment, and environmental and social considerations. Thus, barriers and opportunities for transitioning to low-carbon energy sources must be further examined to secure Nepal's energy independence through hydropower.

Research Overview

With rising urbanization in Nepal, the role of cities in energy transitions is significant for quality of life, socio-economic development, and broadly climate change adaptation. Considering Nepal's vast hydropower potential, hydropower can provide a cleaner alternative to fossil fuels and decrease dependence on Indian imports. In addition to higher energy independence, hydropower directly promotes electric mobility because it is a large, renewable resource and requires relief from electricity surplus.

Globally, there has been a rise in demand for electric vehicles, with Nepal's neighbors India and China providing a model for renewable energy-powered transportation. Already in Nepal, electric vehicles (EV) makes up ten percent of all vehicle sales and has incentives; for example, exemption from road tax and a 10% tax rate on the purchase price, while petroleum and diesel goes up to 261% above the cost price.¹⁷ Despite incentives, it is still difficult to obtain broad public participation in electric mobility.

Since Kathmandu's infrastructure is not suited for fossil fuel alternatives and there are vast hydropower resources, researching issues related to energy and infrastructure is an important task for the environment and energy security. Thus, I explore barriers and opportunities for electric vehicle adoption in Kathmandu. I am using a case study, and my data collection includes document analysis, social media analysis, and interviews with different stakeholders. My discussion centers around the current energy and transportation situation, stakeholder perspectives, and consumer perceptions to find themes and trends of electric mobility in Kathmandu. In reference to these findings, I suggest recommendations that may increase EV adoption.

Literature Review

Because EV technology is still at an early stage and not yet broadly adopted, literature on the topic mainly includes exploratory research and recommendations from observed trends and behavior. Due to proliferating climate change mitigation and adaptation plans, there are different levels of EV diffusion at international, regional, national, and subnational scales. Since electric transportation provides an alternative to fossil fuel-based systems, many actors are interested in this opportunity, whether it be for environmental, economic, or political reasons, and likely a combination of them all. Thus, the literature I review touches on the complex nature of such an energy transition. I begin with an overview of the global market and state of EV diffusion in notable countries. Then, I focus on studies specifically about Nepal's electric mobility, albeit limited. I end with some scholars' conclusions on the effectiveness of certain financial incentives and consumer trends in EV adoption.

Global Market

Globally, the demand for electric vehicles has been rising. For example, EVs have increased to a total of over 5.1 million in 2018, which nearly doubles the amount of new EV sales since the prior year. Furthermore, the global stock of EV passenger vehicles increased by 63% in 2018, exceeding 5 million.¹⁸ Additionally, internal combustion car sales in the first half of 2019 fell by 5%, while electric vehicles increased by 36% (Munoz, 2019).¹⁹ Figure 5 demonstrates EV uptake according to selected countries, indicating that China leads the market. These trends indicate a shift in the global auto market, with companies rolling out plans for more EV models, predicting a market for electric transportation. This has implications on the energy market, particularly for fossil fuels like oil. Numerous countries have developed plans for electric vehicles within this context of changing energy systems, which requires evolving government and business strategies and upgraded infrastructure. Figure 6 demonstrates the development of EV charging infrastructure according to selected countries, indicating that the increase aligns with higher EV diffusion and the most popular are private slow chargers.

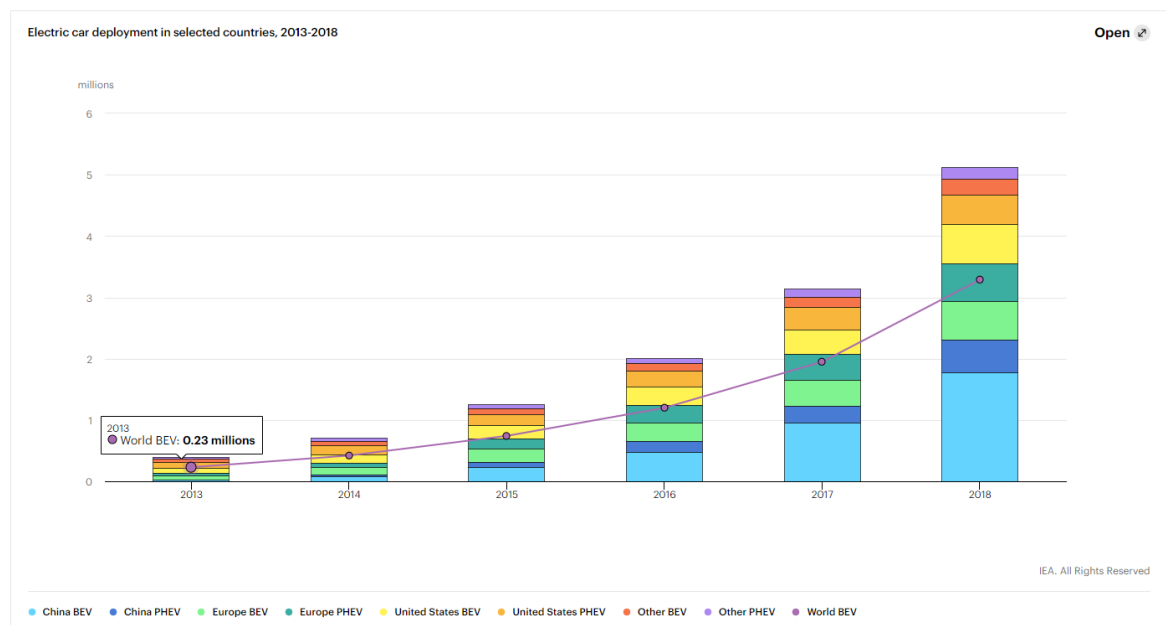


Figure 5. Source adapted from: International Energy Agency. May 2019. “Global EV Outlook 2019.” IEA, Paris. <https://www.iea.org/reports/global-ev-outlook-2019>.

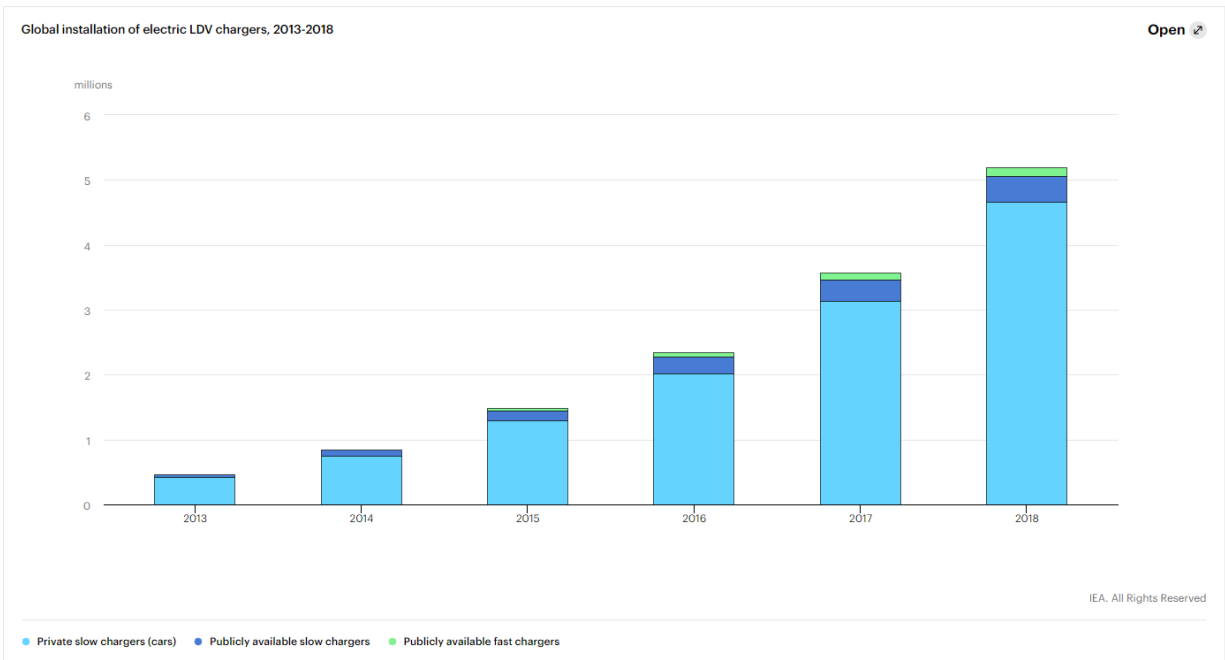


Figure 6. Source adapted from: International Energy Agency. May 2019. “Global EV Outlook 2019.” IEA, Paris. <https://www.iea.org/reports/global-ev-outlook-2019>.

Currently, the biggest market is China, with 2.3 million electric vehicles in 2018, which is 45% of all EVs in the world. Meanwhile, Europe has 1.2 million and the United States 1.1 million EVs (Virta, 2019).²⁰ However, Europe has ambitious transportation goals. To illustrate, Norway seeks 100% of all cars to be either electric or plug-in hybrid by 2025 and the Netherlands wants to ban all gas and diesel car sales by 2025. Germany, France, and Great Britain seek similar goals in later years. Germany wants to ban internal combustion engines by 2030, and France and Great Britain want to end gas and diesel car sales by 2040. On the other hand, the United States has weakened carbon emission standards in transportation (Crabtree, 2019).²¹ Thus, EV may reach 26% of new car sales in Europe by 2030 and just 8% in the US according to the International Energy Agency’s New Policy Scenario. However, China still leads

over countries with a predicted EV share of 28% by 2030. In addition, China has the largest battery manufacturing enterprise, with 60% of the world's total capacity. Overall, China is “well-positioned to benefit economically and politically from the coming global electrification of transportation.”²²

Electric Mobility in Nepal

In the *National Action Plan* (NAP) for Nepal's Nationally Determined Contribution (NDC) under the Paris Agreement, the Global Green Growth Institute (GGGI) evaluates Nepal's energy and transportation policies. They identify trends in “energy consumption, energy dependency and mix, greenhouse gas emissions, and local pollutant emissions” as critical variables for analyzing and projecting the transition to electric transportation.²³ GGGI relies on two studies conducted specifically about Nepal to understand these variables. The first study is by Shakya and Shrestha in 2011. The second study is by Bajracharya and Bhattarai in 2016.

1. Shakya and Shrestha

Shakya and Shrestha discuss changes in the energy sector and GHG emissions from 2005-2050. Figure 7 shows these changes in a business as usual (BAU) scenario, which assumes “current energy use, industry conditions, population growth, and other factors remain the same.” Overall, Figure 7 shows the study's results that the transportation sector will increasingly consume the most energy excluding traditional biomass from 2005-2050.

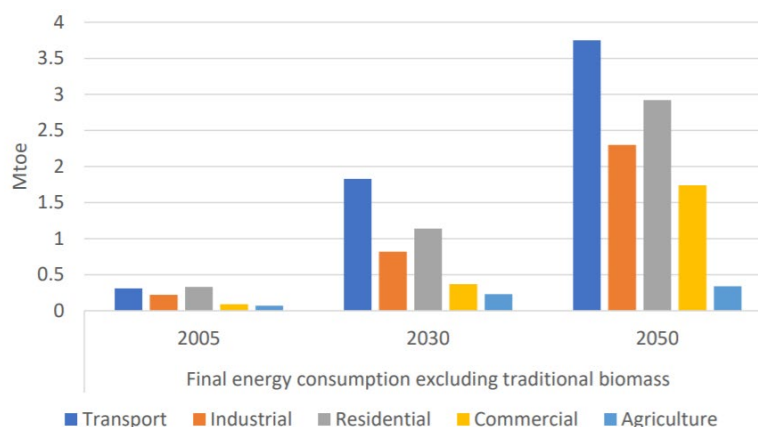


Figure 5.1. Final energy consumption during 2005-2050.⁴⁷
 Source: Adapted from Shakya and Shrestha (2011).

Figure 7. Source adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

The study creates five different scenarios of electric mobility uptake, but only three deemed most in line with the government's *National Development Plan* (NDP) is analyzed in the NAP. To make my literature more concise, I will also follow the three most closely aligned with NAP. The three scenarios include:

1. EMT30: 10% of total transport demand would be met by electric mass transport in 2020, rising to 30% by 2050
2. EMT20+EV10: 20% of total transport demand would be met by electric mass transport in 2015 & 10% of total transport demand would be met through electric passenger vehicles by 2015 remaining constant until 2050
3. EMT20+EV15: 20% of total transport demand would be met by electric mass transport in 2015, remaining constant until 2050 & 10% of total transport demand would be met through electric passenger vehicles by 2015, rising to 15% by 2050

The projections for energy consumption compared across all three scenarios and the BAU (called "base case") in 2030 and 2050 are shown in Figure 8.

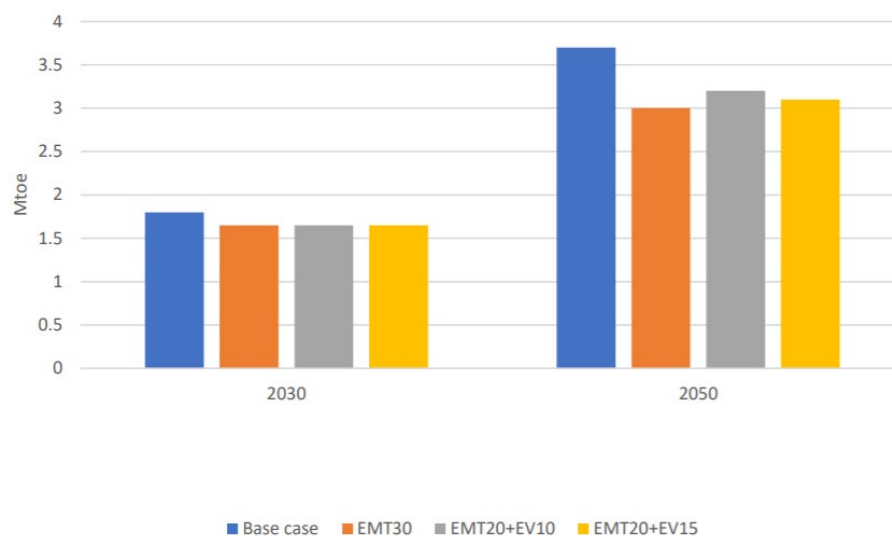


Figure 5.4. Final energy consumption in the transport sector in 2030 and 2050 (Mtoe).

Source: Adapted from Shakya and Shrestha (2011)

Figure 8. Source adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

The projections for greenhouse gas (GHG) emissions in the transport sector compared across all three scenarios and the BAU (called “base case”) in 2030 and 2050 are shown in Figure 9.

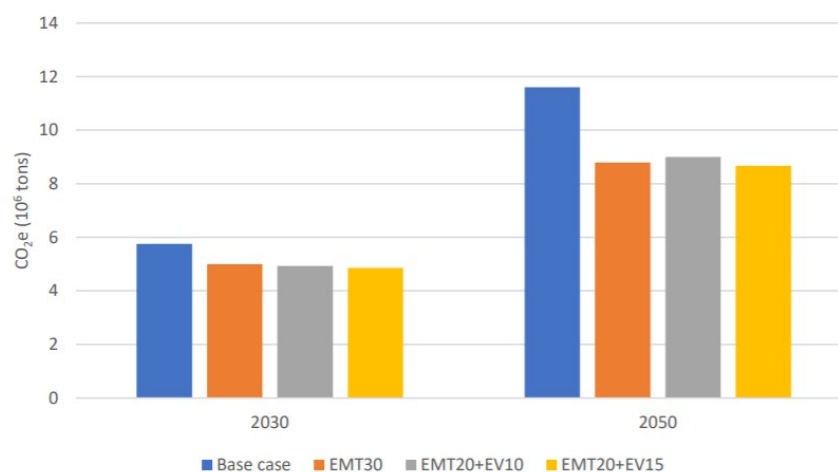


Figure 5.5. Greenhouse gas emissions in the transport sector of Nepal

Source: Shakya and Shrestha (2011)

Figure 9. Source adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

Figure 10 shows how these three scenarios impact energy imports. The Shannon-Wiener Index represents diversification of energy resources.

Table 5.3. Energy security indicators in different scenarios in 2050

Scenario	Net Energy Import Ratio (%)	Shannon-Wiener Index	Oil Consumption per Capita (kgoe/capita)
Base case (BAU)	45.36	1.48	109.75
EMT30	43.37	1.52	91.61
EMT20 + EV10	45.40	1.54	93.01
EMT20 + EV15	44.44	1.54	89.12

Source: Shakya and Shrestha (2011).

Figure 10. Source adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

These three projections of different scenarios convey the benefits of increasing electric mobility in Nepal compared to BAU. There would be less energy consumption, less greenhouse gas emissions, less imported oil, and a more diverse energy mix.

2. Bajracharya and Bhattarai

The study conducted by Bajracharya and Bhattarai in 2016 argues for increasing the share of electric two-wheelers in Kathmandu. For context, the study shows that two-wheelers make up 80% of vehicles in Kathmandu, which means that their share of (GHG) emissions is high. To demonstrate the impact of increasing EVs, they modelled a scenario in which EV scooter sales increased from 1% in 2016 to 75% in 2030. As a result, total energy demand by two-wheelers decreased from 39% in 2010 to 27% by 2030, decreased GHG emissions and pollutants, and increased fuel savings of Rs.52,576 (496USD) from decreased fuel imports. Thus, this study

promotes selling more electric two-wheelers because they make up a large share of vehicles in Kathmandu and can have a relatively large impact.

Financial Incentives

The extent to which financial incentives are effective is debated among scholars and differs among contexts. To study climate policies in 30 United Kingdom cities, Heidrich et. al (2017) analyzed other countries' successes in increasing electric vehicle use, particularly Norway. Heidrich et. al (2017) infers that Norway has been able to raise the EV market share to 29.1% in 2016 due to heavy subsidization that Norway's local governments had the ability to provide, whereas UK's local authorities could not offer as much subsidization. Kester et. al (2018) also agrees that Norway has been able to increase EV sale shares due to this ability, explaining Norway's high tax exemptions that other Nordic countries could not provide, except for Iceland. This scholar goes further in claiming that tax exemption is more effective than subsidies, but this must be considered within local/national/regional contexts. In the United States, financial incentives differ between states, with almost half in 2018 with some kind of "purchase-related financial incentive" (Wee et. al, 2018). Within the U.S., Jin et. al (2014) conclude that direct subsidies have the greatest effect on EV sales (Wee et. al, 2018). Lutsey et. al (2015) find that within the 25 most-populous U.S. metropolitan areas, EVs increase proportionately with diverse incentives (also with charging infrastructure, model availability, and promotions) (Wee et. al, 2018). In China, Qui et. al (2019) claims that EV uptake increases with charging discounts and infrastructure construction subsidies, but not increase strongly with purchase subsidies. Zhang et. al (2013) matches Qiu et. al (2019) by finding a weak relationship between purchase subsidies and buying EVs. This highlights the significance of factors other than financial incentives (Sierzchula et. al, 2014).

Infrastructure

These other factors include infrastructure, such as charging stations and roads for high-occupancy lane access (HOV). Currently, due to the limited range of EVs, charging infrastructure is essential for making electric mobility possible. Kester et. al (2018) recognizes this importance in their study, adding that there also needs to be strategy in finding the proper location for charging stations; for example, even with “significant EV charging infrastructure,” as exemplified by Newcastle, UK, EV drivers still complain primarily about the lack of charging stations. Therefore, perhaps the UK cities with the highest EV sales, London and Birmingham, have a location advantage- London being a hub for government and corporations and Birmingham being the center of the West Midlands car industry (Kester et. al, 2018). This demonstrates a possible advantage for Kathmandu because it is also a hub of government and corporations in Nepal. However, numerous scholars have mentioned the significance of HOV lanes (Wee et. al, 2018), which is not a characteristic currently in Kathmandu. These factors demonstrate that policies and consumer behavior should not be explained simply by financial incentives but requires a holistic perspective including charging locations and suitability of place for electric mobility.

Research Question

What are the opportunities and barriers to electric vehicle development in Nepal?

Methodology

Overview

To understand opportunities and barriers to electric vehicle development in Nepal, I used a case study. I collected primary and secondary data. Primary data consisted of four interviews in the field. Secondary data consisted of policy documents, news articles, and social media. After

data collection, I categorized my findings into three themes: social and market dynamics, technological, and political. In my discussion, I explain opportunities and barriers in each of these themes and provide recommendations on how to increase EV adoption. I conducted both interviews and secondary data analysis to provide a holistic perspective on EV uptake.

Secondary Data Collection

Document analysis included Nepal's *National Action Plan* published in April 2018, in which the government identifies actions and targets for transitioning to a cleaner transportation system including electric mobility. These recommendations are aligned with four transportation targets in Nepal's Nationally Determined Contribution (NDP) under the Paris Agreement. This document gave me a source other than government officials to study government strategies about electric transportation.

My other sources of secondary data included news articles and social media. With this data, I sought to understand public sentiment about electric vehicles. News articles provided a source other than policy documents and interviews to identify progress and changes within the energy and transportation sector. They were particularly valuable for providing comments from high government officials who I could not take an interview with. Social media, specifically Facebook, was used to read customer reviews about EVs. This medium was particularly valuable because it provided more customer feedback than if I were to do a few interviews in-person about driving EVs. In this paper, I selected four customer reviews and one news article headlined on a car company's Facebook page that demonstrated the themes I found about misconceptions of EV performance. I accessed all secondary data through the Internet.

Primary Data

My third method of data collection was interviews with different stakeholders in the energy and transportation sector. These included non-governmental organization (NGO) officials, working groups for EV, and EV salespeople. I conducted a total of three interviews. My first interview was with a working group (a group of companies functioning under one entity to collaborate on projects) that has numerous projects to promote electric mobility. I found this working group online and contacted them via email to interview at their Kathmandu office. My second and third interviews were conducted with EV salespeople, one that works for an electric scooter company and the other that works for a gasoline and electric car company. To access these sites, I visited motor dealerships in Kathmandu and asked for an interview. Each interview was around 30 minutes-1 hour. Questions were semi-structured before the interview. I chose to stop interviews after reaching data saturation, which was reached after four interviews. I assume this is because of the technical nature of EV uptake, since there are more objective factors than a personal narrative of phenomena. This was a purposive sampling because the NGO, working group, and salespeople provided different angles to view the state of EV in Nepal, but within their perspectives were common themes on general opportunities and barriers to EV uptake as shown in my findings.

Ethics

My research followed ethical guidelines, and my research proposal was reviewed and approved by the International Review Board. I did not conduct research with minors or vulnerable populations. Before each interview, I received verbal or written consent. I read my participants their rights, before beginning the interview, which include: voluntary participation, the right to not answer every question, stop the interview at any time, no compensation for interview (they may only receive a copy of this research paper), and identification will remain

anonymous. I audio-recorded my interviews with participant consent. My data is stored on a password-protected laptop. After three years, I will delete this information. All quotes remain anonymous and pseudonyms are used. For pseudonyms, the working group will be referred to as “Working Group,” the car salesperson as “Sales A,” and the electric scooter salesperson as “Sales B.”

Limitations

There are a few limitations to my research. A significant one is time, since I am only conducting research for one month. Thus, the number of stakeholders I had time to interview were low, and I did not have time for different types of data collection and deeper data analysis. Furthermore, I lack expert knowledge on energy and transportation planning and technology. Thus, I could not do scientific and/or environmental analyses of electric mobility in Nepal. Therefore, my findings and conclusions are based on participant knowledge and documents that have open online access. Most technical/scientific information I learned by reading scholarly journals, which I did during the duration of this research to give myself background knowledge and for my literature review. Another limitation is language because I only have Intermediate Nepali skills. Fortunately, my participants could speak English well. However, there is the possibility that complex and/or detailed explanations were dismissed because English is not their first language. Another limitation is biases. My participants may have been biased towards portraying EV in optimistic perspectives because they are promoting EV adoption. For my own biases, I approached the research with some pre-conceived ideas about the opportunities and barriers to EV adoption in Nepal. These were formed from my own experience of Kathmandu, since arriving in August. I noticed the dominance of gasoline vehicles and pollution, as well as lack of charging stations, so I assumed that Nepal was far behind in EV adoption. These biases

may have influenced what questions I ask and led to biased grouping of data into pre-conceived themes.

Findings

Technological

A concise background on EV technology is necessary to provide context for technological findings about EV. This includes battery development and disposal, charging times, and EV infrastructure. After this foundation, the role of the public and private sector in addressing these issues can be better situated within current technological capabilities.

Battery Development

1. Technical Background

The range of an EV depends on the performance and storage capabilities of the battery. Currently, lithium-ion batteries (LIBs) are the dominant technology for transportation and energy storage due to their high-power density and low maintenance cost.²⁴ Basically, batteries produce electricity through an electrolyte medium with electrodes, allowing for the exchange of ions. Battery technology in early EVs included the lead-acid battery developed in 1859 and nickel-cadmium battery developed in 1899. Although the nickel-cadmium battery offers better energy storage than the lead-acid battery, there were problems with memory effect, which is when the battery becomes useless due to voltage suppression. The first LIBs were developed in 1985 and became commercialized six years later. Commercialization was helped by LIB use in consumer technologies, such as smartphones, becoming widespread in the mid-2000s.²⁵ Before the dominance of LIBs, EVs used ZEBRA and Nickel-Metal Hydride batteries.²⁶

LIBs have the advantage over other batteries due to higher efficiency and energy cycle life. This is important because the only power in battery electric vehicles (BEV) comes from an

electric motor, whereas hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) have additional power sources. Thus, BEVs must have a low power-to-energy ratio (P/E), which stands for the power per unit of energy needed for performance. The average compact BEV has 20 kWh capacity and around 1,000 cells, a mid-sized family model has around 30kWh, and luxury models have around 60-100 kWh for longer range and more features. Unfortunately, current LIB technology cannot extend beyond a range of 500 kilometers; the highest LIB power capacity reaches only around half of this range.²⁷

Regarding the global economy of LIBs, the most expensive part of the battery comes from the materials cost, which takes up 60% of the total cost compared to labor and overhead.²⁸ The majority of lithium comes from deposits in Argentina and Chile, and is manufactured in China and Australia. China is a notable player in the global lithium market, known for its manufacturing and consumption of lithium, which consists of nearly 50% of the world's lithium carbonate consumption. Other countries are also dedicating research and development for battery technologies, and LIBs continue to lead the market. Because of this, high production and competition for lithium and other minerals decreases costs, thus decreasing costs for EVs. For example, batteries are estimated to drop to \$109 kW/hour by 2025 and \$73 kW/hour by 2030. Coupling low costs with plans to decrease air pollution through EVs, there is projected potential for 125 million EVs in use by 2030.²⁹

2. Battery Disposal

While this is encouraging for EV development and diffusion, there are sparse battery disposal plans.³⁰ Batteries must be replaced depending on usage and charging frequency. Battery replacement is needed when the battery gives smaller range per charge. This is quantified as charge cycles, and the battery is deemed unusable when it cannot charge above 80%.³¹ The life

cycle for compact cars is 7-10 years, and for larger cars it is 3-4 years. With these metrics, the amount of unusable lithium batteries by 2030 comes to 11 million tons. When unrecycled, this is hazardous to the environment.³² Ongoing research seeks ways to repurpose and recycle disposed batteries. Unfortunately, countries including Nepal do not have battery disposal plans, and until they do, this remains a barrier to sustainable EV use.

3. Stakeholder Perspectives

All stakeholders interviewed highlight the decreasing cost of batteries. Sales A says that the primary reason EVs will be cheaper in the future is because of declining costs and believes that expense will be cut in half 10 years from now. Sales B cites specific numbers- last year the battery price was about \$1300 and currently the price is \$800, projecting that in 4-5 years the price will be \$300. They reason this is because lithium production is increasing every year. Working Group provides a lengthier explanation of battery development. They emphasize that batteries are manufactured outside of Nepal, thus hiking up the price of EVs. According to them, this could be mitigated by building a battery assembly line within Nepal, which is one of their planned business projects. They explain that the battery pack is made up of “thousands of cells” and that each cell currently costs \$1 to replace, whereas 5 years ago it cost \$5. They also note the savings of replacing an individual cell versus replacing an entire battery pack, which can cost thousands of dollars, especially since there is overseas business involved. It is also true that other stakeholders’ batteries are manufactured outside of Nepal. Sales A’s batteries are from a third party manufacturer, which the salesperson cannot recall during the interview. Sales B’s batteries are manufactured in China, and Working Group does all their business with China.

Infrastructure

Common consensus among stakeholders, documents, and media note the lack of infrastructure necessary for mass participation in electric transport. Current developments in Nepal require a significant amount of public and private investment/public-private collaborations to build critical infrastructure.

1. Public Sector

Major actors in the public sector are The Energy Ministry and Nepal Electricity Authority (NEA), who holds regulatory authority over charging infrastructure. In the next one and a half years, NEA plans to establish 50 charging stations in the main cities and highways of Nepal. They will be set up in the Kathmandu Valley first, and then in places like Pokhara, Nepalgunj, Chitwan and Biratnagar. The plan indicates that there will be a charging station every 100-200 kilometers along the highway and can charge a minimum of three vehicles at a time. The plan also helps property owners, who can open up their land to build stations, which can increase business, and targets areas with bigger parking lots.³³ NEA supplies the electricity. As of mid-November 2019, construction bids were yet to be sent out for the 50 charging stations because technical documents needed to be finished, but they should be done in December.³⁴ Currently, there is a charging station for EVs at NEA in Ratnapark, Kathmandu.³⁵

2. Public-Private Collaboration

An important element in building EV infrastructure is both public and private investment. As such, the Energy Ministry incentivizes private investment in charging stations by allowing private actors to take up to a 20% service charge from EV drivers. A slow charging operator can receive 15% service charge, and a fast charging operator can receive 20% service charge. For EV consumers who want to set up a household charging station, they pay the current electricity tariff

on household consumption and must pass the required load level to receive a permit from the NEA.³⁶

Earlier this year, the Electricity Regulatory Commission had been developing tariffs for electricity sold through charging stations. In mid-November, private companies told the *Kathmandu Post* that they want fixed charging rates before they increase investment in charging stations. Therefore, the NEA has proposed a tariff revision that would do so. The NEA plans these rates for medium voltage:

Per Month	Rs255
Peak Hours	Rs9.35/unit
Night Hours	Rs3.70/unit
Odd Hours	Rs8.40/unit

These rates are higher than those for public transportation. However, the proposed tariffs must receive approval from the Electricity Regulatory Commission.³⁷

3. Private Sector

According to Working Group, they have helped install two charging stations, such as one midway on the highway to Pokhara. They are also enthusiastic about their plans to build more charging infrastructure, saying it will be here in the next few months. Notable about this company is their initiative to create rest areas with extensive facilities. They describe the rest areas as this:

We don't have rest areas like in US like on our highways. There are many small shops but not a proper rest area where you can go relax, go to nice restroom, have good food. So we are trying to. It is a part of that ecosystem of EV infrastructure that I was planning. It is also already getting ready. We have already bought a land. It will have charging stations. For bus, car, everything. So you can go, next time when you're here and go to Pokhara, you can go there and it will add up to your carbon offsetting because you'll be using the energy here from solar or biogas. These are the features we have here: restaurant, motel, coffeshop, mart, restrooms, charging stations, free WiFi, information center, even massage.

Particularly striking about this explanation is the apparent rapidity of the process, with land already bought, and optimism about efficient completion.

Another finding from private stakeholders is the establishment of charging stations on their company premises and at sister companies. For Sales A's cars, there are 6-7 charging stations in Kathmandu. These are in the showrooms and service stations and are free of cost. Additional charging stations are at the Marriot Hotel in Naxal and Labim Mall in Patan. These ones are AC charging stations, not DC, which means they are slow charging stations. The regular range car can go 300-350km maximum. For the long range, it takes around 26 hours and for the regular range, it takes around 19 hours to completely charge. Thus, with these current technical logistics, Sales A says the vehicle must be parked at one place to charge, which is usually done at the home.

For Sales B's scooters, there are two ways to charge the scooter, which inherently increases charging options. One way is to charge the battery while it is in the scooter. However, if there is not a charging outlet near the parked scooter, the battery can be taken out of the scooter and charged at an indoor outlet, like laptop charging. Sales B says this makes charging easier because there are not enough stations in Nepal. They emphasize this ease since the scooter battery can charge like a laptop, and identifies sister companies in Kathmandu that have outlets available for charging, such as at one of the Iphone stores. On a full charge, Sales B's scooters can go up to 80km and takes 6 hours to fully charge. With these metrics, the salesperson says it is mainly for city-use.

Sundar Yatayat Pvt has also developed charging stations. There are three charging stations installed with 30 kW, 60 kW, and 120 kW charging ports.³⁸ They are located in Chabahil, Sukhedhara, and Sitapaila. Sundar Yatayat currently operates four electric buses in

Kathmandu, with plans to purchase more and expand routes outside of Kathmandu within a year. Thus, charging stations in other areas like Biratnagar and Butwal are being contemplated. These charging stations are for all models of private electric vehicles and takes four to six hours to completely charge.³⁹

Social and Market Dynamics

Social and market opportunities and barriers of EV adoption in Nepal is demonstrated through consumer behavior in the EV market. This is analyzed through EV sales trends, marketing strategies, and customer feedback.

EV Sales

Despite technological limitations, EV sales have been increasing. Multiple stakeholder companies confirm this trend. For example, Working Group declares boldly, “Oh it [EV sales in Kathmandu] is increasing like anything. So maybe next few years, the growth rate will be more than 1000%.” However, this statement is followed with clarification that EVs are only 3% of Kathmandu’s total vehicles, which is why there is potential for such large growth. Furthermore, electric scooter sales for Sales B have increased by 20% compared to previous years, and Sales A also describes the increase as “drastic.”

Marketing Strategies

1. Model Diversity

As a result of this trend, motor dealers are encouraged to include more EV models in their lineup as customer preferences become better known. This is conveyed in an interview with Sales A, who narrates the chronology of available EV models in their company. Sales A launched its first EV in Nepal, the Ioniq, in September 2018, which the company official declares the reasons is due to the “high demand and popularity of electric cars throughout the

world.”⁴⁰ According to Sales A, the Ioniq did “really well,” and following this success was the launch of their second EV model, the KONA, at the end of the same year. This second launch was more popular because the KONA is an SUV, which people prefer over a sedan like the Ioniq. The KONA also has two range options- regular range or long range. The regular range can go 300km at a price of Rs.51,96,000 and long range can go 480km at a price of Rs.65,96,000. Comparing regular and long range, Sales A says the KONA regular range is more popular because customers buy electric for the city. Therefore, long range is not essential, since the maximum drive is 50km/day in Kathmandu. Thus, customers can save money by opting for the regular range.

In addition to Sales A’s company, Working Group also conveys that increased EV adoption aligns with more availability of EV models. Working Group has multiple EV models that they plan to launch in a few months. Working Group explains their models, starting with an EV car that will be one of the least expensive EV cars currently available, priced at two million rupees. It is a low speed car, running at a maximum speed of 70 miles/hour but usually running at 45 miles/hour and a range of 300km. The official notes that within the context of Kathmandu, cars do not even go that fast on highways, so speed is not a practical concern when reasoning with customers. Next, the official promotes an EV model targeted for rural people. They explain that most people in rural areas are too poor to afford more than one gasoline two-wheeler per house. This is detrimental because the productivity of a two-wheeler is low, viewing the situation as this:

So this is another vehicle. For villages. In villages, they usually have two-wheeler. Gasoline two-wheeler. Poorest and poorest people have two-wheelers. Just one per house. And all family lives in one room. And they have just one two -heeler. It is similar to status symbol. Something like that. But the productivity of two-wheeler is not much. You cannot load your product and your friend and send that into the market. And if somebody gets sick in the middle of the night, you cannot

take him on two-wheeler to the hospital... Even there are not many petrol stations nearby villages. So to fill up the petrol, they have to spend 2 liter of petrol because 2-3 liter to go come back. So they just waste 2 liters of petrol. . . So if they [villagers] have something like this vehicle, they can use it for commuting, to load cargo, they can use it to load their product and go to the market to sell it. And they can sometimes in emergency to use it to go to the hospital. So this is the main thinking to get this vehicle.

Thus, the vehicle may help productivity in villages, and also replace gasoline vehicles with electric vehicles. Working Group finishes their presentation on models with large passenger vehicles. These include an 11-seater van, 20-seater van, and a bus. They justify the need for EV large passenger models because in remote places, old and diesel vehicles are used as passenger vehicles. They lament on this:

Diesel, petrol, very old. Not a passenger vehicle but they convert it to a passenger vehicle. Not very comfortable, so I thought every passenger has rights. . . They have rights to have a nice feeling.

Thus, these models will replace old, diesel vehicles with electric, comfortable vehicles that can fit a large passenger load. The goal for these projects is to provide EV models that will replace the equivalent gasoline/diesel models while simultaneously increasing their productivity.

Another element of model diversity is the features in Sales B's electric scooters. In my interview with Sales B, they emphasized its smart features because is the only company to provide smart features. They boast:

It is first smart electric scooter in the world. You can do the GPS tracking with this scooter. You can just download the apps. There is an application in the app store. Then from that app you can do everything. GPS tracking. How much is the battery you can see through the mobile. And the riding status. How long you run in a week. You can check everything, you know? And that is why this is smart electric scooter.

When asked about the major selling points, they identify smart features as one of them because it may relieve anxiety about range and charging logistics. Furthermore, Sales B claims to have no

competitors due to this distinguishing feature, since it is not available in other companies' electric scooters.

2. Demographic Target

Another marketing strategy is targeting a demographic to increase the chances that certain consumers will purchase the best fitting EV model. This is common amongst all brands interviewed. However, Sales A's target differs from Sales B and Working Group. Sales A sells two kinds of electric cars, Ioniq and KONA, which are priced at the higher end of the spectrum from EVs. Thus, Sales A adopts marketing that designates these cars as a luxury brand. For example, the Sales A uses the phrase "top notch" in this quotation:

Features are like- you get almost everything. The interior is really good: leather finishing, Rubberized material dashboards, soft touches on dashboard and armrest. Everything interior is really good. Even the exterior. Like the headlamps are non-projector headlamps, which are like top-notch features.

On the website for Sales A's EVs, there is also an element of excess comfort and expansiveness to describe the car. To illustrate:

The All-New KONA Electric is designed to fit everything you and your busy life can throw at it – with plenty of room for both passengers and cargo with a trunk capacity of 373L (VDA). But it's also the attention to detail that makes it so special. Discover an exceptional level of comfort with high quality materials throughout for a sensuous and refined feel. Adjustable power front seats with heating and ventilation and a heated steering wheel are also available for even more comfort.

Phrases like "sensuous and refined feel," "seats with heating and ventilation," "heated steering wheeling," and "plenty of room for both passengers and cargo" portray the EVs as not comprising on the luxury features found in gasoline luxury cars. Thus, high-end customers can maintain their status symbol while transitioning to electric.

On the other hand, Sales B and Working Group target a different demographic to increase EV appeal to consumers. Whereas Sales A sells both gasoline and EVs, Sales B and Working Group are exclusively electric. Therefore, marketing attempts are aimed at combating common misconceptions of EVs, notably their low cost and ease of driving experience. When asked about their scooter's popularity, the Sales A responds, "Because look, price is good, double seater ... The main thing is the cheaper one with a good quality." When analyzing the company's Facebook page, there are posts about bank loans, frequently asked questions on the home page about price ("What are the different models with prices?" and "How do I finance. . .?"), and customer testimonials of the quietness and powerful performance of the motors. Sales A's Nepal Facebook page mainly has feed for announcing contests and dates of festivals, as if their company has nothing to prove in regard to power, performance, and cost since it is an established, high-end luxury car in Nepal.

The demographic that Working Group targets is the average person, one who cannot afford the standard price of an electric car but not wanting to settle for a simple two-wheeler. Appealing to average consumers was actually a large part of the reason for starting the company. Working Group describes the situation with this narration:

If you ask me, there was an Indian company, they are selling EVs from last 5 years. But in very limited numbers. And some other company from Korea, like KIA. They started maybe 2 years ago. Now there are a few other companies who are also selling EVs. But those EV's price are very high for our market. I used to be sole distributor for KIA EVs. When we were selling the KIA EV, we couldn't sell much, not in volume. So suddenly I thought like this is not our values. I was not thinking of selling only 100 cars a year, which cannot change anything. It cannot reduce the fossil fuel we import from India. It cannot reduce the environmental issues. Just selling 100-200 cars, not gonna solve any problem. That's why I chose to begin reasonably-priced EVs.

An example of a "reasonably-priced" EV that Working Group will sell is a car at a price of 2 million Nepali rupees. According to them, EVs that sell within a lower price range will reach

more consumers because they are more affordable, implying that high purchase costs is a major detriment to transitioning to EVs.

Financial Incentives

Although different companies sell EVs at different prices, subsidies are provided that benefit the entire industry to help overcome high purchase costs. Through subsidies, the government demonstrates commitment to electric mobility by providing tax exemptions and custom tariffs for EVs. For example, there is a 10 percent import tax and 13 percent value-added tax (VAT), taxing EVs at only 23 percent. Public EVs that carry more than 14 passengers have a 1 percent import tax and 13 percent VAT, giving a total tax of 14 percent. This is a huge advantage since gasoline and diesel vehicles adopt taxes up to 261 percent.⁴¹ Furthermore, there is exemption from road tax for electric vehicles, whereas gasoline and diesel vehicles pay road tax between 30-50,000 Nepali rupees annually.⁴²

When asked about the assistance of these government subsidies, the Sales A and Sales B are content with the incentives provided by the government. They both identify the custom tariff and link the annual road tax exemption as a primary reason people go electric. Also, they believe people are aware of subsidies, so information is not necessarily a major issue regarding government incentives. Furthermore, Sales A notes that banks are financing EV purchases. For example, for diesel and gasoline vehicles only 50% is financed, but for EVs the bank is willing to finance up to 80%. Sales A also recommends that manufacturers provide subsidies, in addition to the government, so options are increased for dealers. Working Group is the only stakeholder interviewer that brought up the concern of government failing to sustain their subsidies. They note that this is worrisome because the custom tariff and tax exemption allow for EVs to compete with gasoline and diesel vehicles. In their words:

But if government fails... we are losing our tax, and they raise the custom duty on EV. Then again, we are doomed. And all of these initiatives are doomed too.

These insights all point towards the essentiality of subsidies for greater EV adoption. They allow EVs to be sold at a lower price, so more consumers can afford the switch from gasoline to diesel.

Social Conceptions

There are standard conceptions that the public has of EV. These commonly include concerns about range anxiety, power, and high expense. When interviewing stakeholders, they cited these concerns and referred to them mainly as “misconceptions.” Furthermore, these concerns are evident in customer reviews about EVs that were found on social media.

1. Stakeholder Perspectives

Overall, stakeholders agree that there is lack of confidence in EVs. Therefore, a large majority of EV promotion involves getting over customers’ misconceptions. All companies cited the import of cheap, electric Chinese motorbikes around ten years ago as a major source of the problem. Because these bikes from China were poorly made and cheap, they did not perform well. One stakeholder recalls:

It’s cheaper one, and then it does not last for long. Then, it came that year and second year, it vanished. No company, nothing. Because of that reason, people’s minds are still blocked. They are thinking electric vehicle of that age.

Thus, the public needs to be cleared of this doubt harvested years ago. After taking EVs for a test drive, companies noted that the customers are pleasantly surprised with the driving experience. One company conveys that the customers “are very happy driving the electric. No vibrations, no noise, and pretty much less maintenance cost.” Rather, there is only the relatively minor concern of ground clearance after purchasing an EV.

However, a major concern is range anxiety. This is anxiety over whether an EV will go enough distance per charge, largely due to lack of charging stations in Nepal. Even one of the

officials interviewed admitted that one of their cars is an EV, but they cannot use because of limited range. They reason:

I have three electric cars and one diesel SUV. Because I have to go around to other cities, most of the time EV is not very practical as of now because we don't have charging stations in many places. But later on, when they have enough charging stations, I will sell that vehicle [diesel vehicle]. But by compulsion, I have to keep one diesel SUV.

Similar to this stakeholder, the majority of people who buy an EV already have another car. They buy an EV mainly for city use due to performance concerns and range anxiety exacerbated by poor EV infrastructure.

Another primary misconception evident in stakeholder interviews is power and performance. To illustrate, Sales A says that the first question and doubt that customers bring up is that the electric will not perform like a gasoline or diesel vehicle. The salesperson elaborates:

They want to know firstly if the EVs are good enough for power and performance because they generally think that the power of an EV won't be much powerful than the gasoline or diesel. That's misconception.

In response to customers doubting the EV's performance, Sales A attempts to convince them through "the specs." They explain ("AK" is myself):

Sales A: Like the torque that it generates, the power. Power it has in the motor. The second thing that we do is let them drive the vehicle itself. Then it's so simple that after driving about 10-20 seconds they realize that it's something different.

AK: how is it different?

Sales A: It's kind-of really fun to drive because the torque is like instantly released. When you drive an EV, the first thing that you feel when you press the gas pedal, it releases the torque so instantly that it's almost like driving a sports car. It's really fun to drive. The reason behind it, EV motor doesn't need to burn the fuel and everything that happens in an engine.

In this explanation, the customer is given numerous reasons to believe that an EV can be just as good, if not better, than gasoline and diesel. There is a technical explanation of how an electric motor runs in comparison to gasoline, which allows for faster torque power. Furthermore, the

customer can feel this difference when taking it on a test drive. Therefore, there is a rational explanation and a personal experience to erase misconceptions about poor power and performance of an EV.

Another perception of EVs is the high cost, which is more reflective of reality than a mere misconception. Although there are government financial incentives and special bank loans for EVs, the upfront cost is higher than a gasoline/diesel vehicle. The stakeholders do emphasize that EV is cheaper in the long-term, due to lower maintenance and operational costs. However, consumers are concerned about the cost of a battery replacement, which is costly at the moment because there is not a battery assembly line in Nepal. However, one stakeholder dismisses this, since their company is planning a battery assembly line in Nepal, so replacements can be done at minimum price. Regardless, battery repairs are still a costly complication; hopefully, this will not be required for the full battery life expectancy, lasting around 10 years. Some companies aim to alleviate this worry through offering a period, such as two years, of battery warranty. Overall, if consumers want an EV and have low price as a priority, they opt for a two-wheeler because they are cheaper.

2. Public Perceptions of EV on Social Media

To further understand the public's perception of EVs, I selected reviews about EV cars and scooters that were found on various motor companies' Facebook pages. I selected each review that highlighted themes of consumer misconceptions identified by the stakeholders interviewed. These include EV purchase cost and operational cost, power and performance, and cars versus two-wheelers.

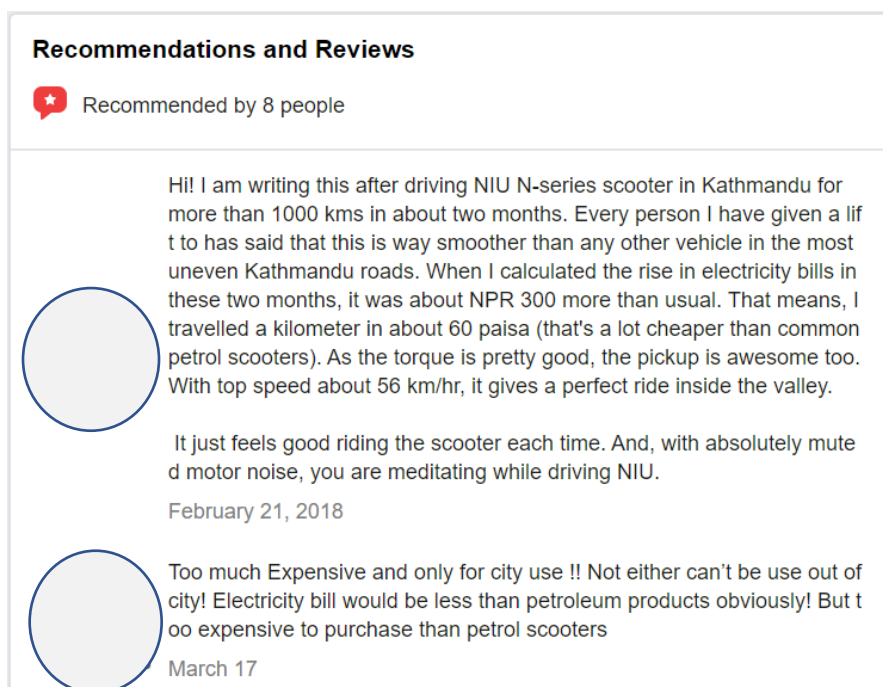


Figure 11. Source adapted from: Facebook.com

Figure 11 includes two comments that discuss the same factors about the same company, but they develop two different reactions. The first reviewer spent more on the electricity bill than usual; however, they believe that the extra expense is worth it because the end result is still cheaper than a petrol scooter. The second reviewer acknowledges that paying the electricity bill would be cheaper than petrol, but to purchase the scooter is too expensive, especially just for city use. Thus, it can be inferred that the barrier for some consumers is not operating costs (like charging), but a high upfront purchase cost.



Figure 12. Source adapted from: Facebook.com

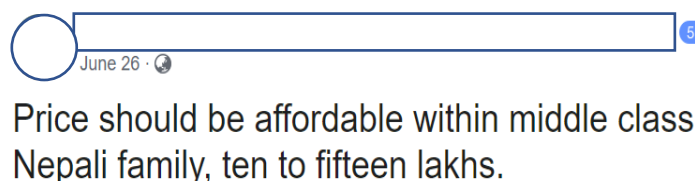


Figure 13. Source adapted from: Facebook.com

The headline in Figure 12 is notable because it demonstrates the price gap between electric cars and motorcycles. It can be inferred that consumers are more comfortable paying the price of a two-wheeler than a car, and it is surprising that an electric car can be sold and bought at a comparable price. The comment in Figure 13 is direct in their complaint that EVs are simply unaffordable for the Nepali middle class. This is of significance because Nepal's demographic is mainly low and middle-income classes.

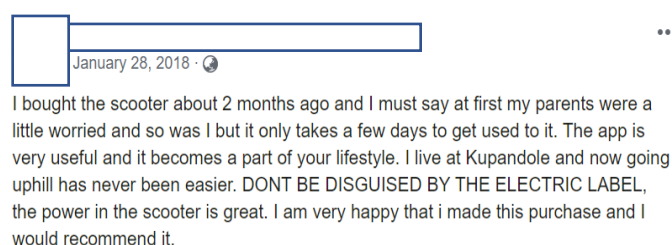


Figure 14. Source adapted from: Facebook.com

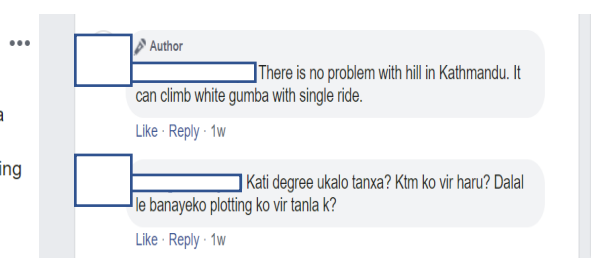


Figure 15. Source adapted from: Facebook.com

The reviews in Figure 14 and Figure 15 are notable because they convey the common conception that electric motors are not powerful. The review in Figure 14 highlights the concern of hills, which the company confidently addresses is actually not an issue to be worried about. The

comment in Figure 15 directly links the “electric label” as being a turnoff due to weak power; however, this misconception is debunked once driving the EV.

Political

Government Plan

As a member of the Paris Agreement, Nepal has a Nationally Determined Contribution (NDC), which is a specific plan that each country develops as part of global action to address climate change. In Nepal’s NDC, there are fourteen targets, four of which involve the transport sector. These include:

- By 2020, Nepal aims to increase the share of electric vehicles up to 20% from 2010 level.
- By 2050, Nepal will decrease its dependency on fossils in the transport sector by 50% through effective mass public transport means while promoting energy efficient and electrical vehicles.
- Nepal will develop its electrical (hydro-powered) rail network by 2040 to support mass transportation of goods and public commuting.
- By 2025, Nepal will strive to decrease the rate of air pollution through proper monitoring of sources of air pollutants like wastes, old and unmaintained vehicles, and industries.

Specific evaluation of transportation is analyzed in the *National Action Plan* published in April 2018, in which the government identifies actions and targets for transitioning to a cleaner transportation system, such as through electric mobility. As part of this transition, numerous policy recommendations and actions are iterated to reach the four targets above.⁴³ These include:

	BARRIER	INITIATIVE	PRIORITY ACTION
POLICY AND GOVERNANCE	1. Limited operational action	1. Develop directive for electric mobility 2. Change legislation for police empowerment on polluting vehicles 3. Develop guidelines for vehicle conversion and/or hybridization	National program
	2. Insufficient management of vehicle operators	4. Reform route and permit management for electric public transport 5. Reconsider ban on additional electric three-wheelers	National program
	3. Limited governance of vehicle distributors	12. Incentivize new entrants on the electric mobility market	National program; National financing vehicle
	4. Restrained political support and coordination	[See Priority Action 2]	National unit

INFRASTRUCTURE AND MARKETS	5. Insufficient investment in facilities	7. Identify and co-fund charging infrastructure projects 8. Identify and co-fund battery recycling 19. Improve banking for electric mobility businesses	National program; National financing vehicle
	6. Limited investment in mass transportation	9. Advance electric rail initiatives 10. Advance electric urban mass transportation initiatives	National taskforce
	7. Electric vehicles priced as luxury goods	11. Support local electric vehicle assembly or manufacturing projects 12. Incentivize new entrants on the electric mobility market	National financing vehicle
	8. Uncertainty of electricity supply and cost	13. Promote the introduction of time-of-day metering at homes 14. Improve reliability of electricity supply, including voltage fluctuation	National program; National unit
	9. Under-development of markets	15. Develop informational campaign for electric mobility 16. Development government fleet of electric vehicles 19. Improve banking for electric mobility businesses	National program
	10. Under-development of electric two-wheeler market	6. Ease restrictions on electric two-wheelers 17. Foster supply of electric two-wheelers 19. Improve banking for electric mobility businesses	National program; National financing vehicle

FINANCING AND RESOURCES	11. Limited government incentive	18. Establish a national subsidy scheme	National financing vehicle
	12. Vulnerability of federal revenue	20. Undertake an economic analysis of long-term implications	National program
	13. Limited human resources	21. Establish centers of excellence 22. Develop training program for engineers	National program
	14. Restrained entrepreneurship	19. Improve banking for electric mobility businesses	National financing vehicle

DATA AND MONITORING	15. Insufficient data collection and access	23. Improve data collection on vehicle registration and sc4apping 24. Establish data collection and sharing protocol for air quality data	National program; National unit
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Figure 16. Sources adapted from: Global Green Growth Institute. April 2018. *National Action Plan for Electric Mobility: Accelerating Implementation of Nepal's Nationally Determined Contribution*. Seoul: Global Green Growth Institute. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Action-Plan-for-Electric-Mobility.pdf.

Energy Security

Nepal's transportation sector is currently dominated by gasoline and diesel vehicles. However, Nepal does not have its own source of petroleum. Rather, Nepal has to import fuel from India, spending Rs.155.43billion on petrol and diesel imports. This is an increase of over Rs.30billion from the 2017/2018 fiscal year. Paired with rising gasoline/diesel vehicles, importing fossil fuels is a significant expense for Nepal and increases the trade deficit.⁴⁴ Not only does dependence on imported fuel cost Nepal economically, but energy security is undermined. This issue has played out in recent history, both in 1989 and 2015. In 1989, India placed an embargo on Nepal, and in 2015, a blockade with India stopped petroleum imports, both instances leading to fuel scarcity. For instance, 75% of transportation stopped in 2015. The aftershock of these incidents led to renewed interest in alternative energy sources, such as hydropower and electric mobility. For example, after the 1989 embargo, the Volkswagen Beetle was converted to an EV in 1992, which ended up not being economically viable. However, it led to the launching of electric Safa Tempos.⁴⁵ Similarly, because of the fuel crisis resulting from the 2015 blockade, there was refreshed opportunity for policy shifts that would reduce the trade deficit and increase electric transportation and appliances, rather than rely on imported fossil fuels. This can be achieved through hydropower, of which Nepal has about 43,000MW of hydroelectric potential that is economically viable.⁴⁶ Electric mobility has a specific role to play

in increased hydroelectricity because it could relieve electricity surplus.⁴⁷ Because hydropower sources 95% of electricity in Nepal, there is a fundamental link between promoting electric mobility and developing hydropower.⁴⁸

Stakeholder Perspectives

Working Group recognizes the connection between economics and energy dependence, including these two themes in their business vision. There is awareness of Nepal's position global position in this exchange (Working Group called "WG"):

WG: Basically for other countries, all other things are same. But this one is very important for us... the trade deficit around 35-40% is petroleum product.

AK: That's a huge ratio.

WG: It's huge. We can save a lot of money. And on top of that, India does blocking of the border sometimes to give us more trouble. So if we have more electric vehicle. . .

AK: You don't have to worry.

WG: Yeah, we don't have to worry. So that's why I told you I link our independence with energy, not in political relation of two countries. They don't have to fight with us. They don't have to come with guns. They just have to block our border and don't let petroleum products come to us and we are doomed.

While there is a political element in this perspective, since they directly explain national independence and international relations, Sales A only explains energy security on economic terms. In response to why EV is good or bad for Kathmandu, they respond:

I think not really Kathmandu city, but for Nepal as well. It's very much I think good because the main thing that we have is electricity. That's going to be huge. One of the huge things for Nepal- electricity. If we could use the EVs, then first thing is the gasoline and diesel import will be less, less importing... The money remains in the country itself if we just use electricity. . . Trade deficit would be less. That's the good thing.

Here, the primary emphasis is that EV will save Nepal money because they do not have to import energy; instead, Nepal can use electricity that it has in abundance domestically.

Discussion

Social/Market Barriers and Opportunities

Social and market barriers can be explained by the perception of EVs as a luxury brand, rather than a practical option for the average consumer. This is exemplified by the mission of Working Group, who identified this issue while selling EV cars for KIA. KIA EVs were not sold in a large volume, which cannot bring a significant change. Based on participant interviews and social media reviews, I assume this is due to the relative high cost of purchasing a car in Kathmandu, which is demonstrated by the social media review that said an affordable price for a Nepali middle class family is between ten to fifteen lakhs, not 66 lakhs like these KIA cars. Another reason to assume higher purchase costs are a barrier for the average consumer is the demographic who buys EV. To illustrate, the demographic largely includes higher-income consumers, conveyed not only by the ability to simply purchase the car, but the ownership of multiple cars already. For example, the companies interviewed said that the customers who buy electric already have other cars and just want to keep an electric for the city.

Buying an EV mainly for city use touches on another barrier to EV uptake, which is their practicality for use within Kathmandu. The stakeholders convey that many customers believe they drive further in one day than an EV could handle, contributing to range anxiety. However, this is a misconception because EVs can go further on one charge than the maximum average daily commute of 50km, instead reaching up to 80km for a scooter and 350km for a car. Along with this are concerns about power, charging time, and operational costs as explained in my findings. These factors lead to uncertainty about EVs, which can be overcome through awareness and information campaigns.

As is common with new technologies, the average consumer is hesitant to purchase due to misinformation and unknown durability of the new technology. In Kathmandu, lack of knowledge about EV technology is more significant than lack of knowledge about financial incentives. My findings convey this because all participants said that customers are aware of financial assistance; rather, the major reason for not going electric is concerns about EV technology, which include battery, range, and power.

A tentative market trend in my findings is that when EV model options increase, EV sales increase. This makes sense because there are more models to fit the needs and preferences of different consumers. For example, according to my findings, Sales A's company released their first EV in the Fall and their second EV at the end of the same year. Their second EV launch sold out quickly, since the SUV model is preferred over the sedan model, which was the first launch. Furthermore, the second launch had two options- regular range and long range. Because the customers were looking for an EV just for city use, they had the option to choose regular range, since longer range was not required for intra-city travel and it was cheaper. Therefore, having two options gives customers more choice and control during the purchase. Within the context of EVs, having range options allows consumers to organize their priorities regarding distance and cost. If range anxiety is a particular stressor, consumers may opt to pay more in purchase costs for longer range to relieve range anxiety. On the other hand, if purchase costs are a major priority for consumers, there should be EVs that accommodate these consumers.

The only EVs in a lower price range are two-wheelers. Regarding cars, my research did not find a lower price car, which could be considered as around Rs.1-2 million; however, Working Group hopes to release a reasonably-priced car of this price point within a few months. Still, two-wheelers are the only cheaper options that are also electric. This is not necessarily

detrimental because motorbikes are a popular vehicle in Kathmandu for local transportation- and may even be the preferred EV model over cars. For example, the study by Bajracharya and Bhattarai shows that two-wheelers make up 80% of vehicles in Kathmandu. Thus, both customer preference and EV benefits could be met by higher EV two-wheeler consumers. The study illustrates this scenario leading to reductions in energy demand, greenhouse gases and pollutants, and reduced fuel imports (if electric two-wheelers have a sales increase of 75% by 2030 compared to 1% in 2010).⁴⁹ Therefore, manufacturers and importers/distributors should recognize the preference of two-wheelers and the need for lower cost car options. By catering to popular demand of two-wheelers, which are inherently the least expensive EV, EV diffusion could increase faster because it is more affordable. This helps overcome the major social barrier of uncertainty, since more people ease familiarity with EV technology through two-wheelers.

Along with the available EV models, the location of EV manufacturing plays an important role for multiple reasons. A large reason for the high purchase cost and expensive battery replacement is overseas business and foreign manufacturing. There is government assistance through customs tariffs for EV, but local manufacturing and/or assembling could create a domestic market for lower-priced EVs. According to the government's *National Action Plan*, ways to stimulate local development of EV manufacturing/assembling is entrepreneurship that uses the experience in the manufacture of electric three-wheelers, as well as financial support for start-ups through co-funding and/or bank financing.

Technological Barriers and Opportunities

Technological barriers can be overcome by increasing research and development on EV technology and infrastructure. Unfortunately, improving technology and infrastructure requires significant public and private investment. Based on participant interviews, stakeholders are

content with the financial incentives currently in place. For example, salespeople stated that customers are aware of financial assistance, specifically finding the road tax exemption as an enticing reason to go electric. That being true, and even if cost is not a concern, a critical barrier is the absence of EV infrastructure.

To obtain investment to update infrastructure requires further public and private collaborations. In the *National Action Plan*, there is outlined a national financing plan that is co-funded with the private sector. According to the *National Action Plan*, there are multiple ways to finance the national plan, such as through the pollution tax and national/international grants. Not only will this finance electric mobility projects, but it will signal public-private commitment to EV development; thus, there will be more confidence to invest and purchase EVs as required facilities and infrastructure are built. Examples of EV projects include charging stations, ICE conversion to EVs, EV taxis, and EVs for tourism.

When developing EV infrastructure, it is important to consider how driving experiences change with EV. For example, charging times can take nearly 30 hours for slow chargers and 5 hours for fast chargers. Charging that is not 0-100% could also be as little as 30 minutes-1 hour with fast chargers. With these logistical complications, many consumers will simply opt to charge their vehicles at home during the night. However, the availability of public charging stations is essential to allow mass participation, especially for long-distance travel. Moreover, there should be strategic locations of stations, such as where cars are parked for long times like at workplaces. Examples of these strategic locations are found in cities with higher EV diffusion as explained in my literature review. Unfortunately for Nepal, the availability of large parking lots in Kathmandu is scarce, and the hilly terrain for cross-country travel sets up unique barriers. Regardless, the government has plans that incorporate convenience as much as possible; for

example, along highways, charging stations are to be built every 100-200km. Also, public-private sectors are working together; to illustrate, the private sector can install charging facilities on land opened up by the public sector, allowing joint investment for charging stations. There are even ambitious plans by the private sector to open up rest areas, such as the Working Group, who wants to build rest areas that have extensive features including a motel, restaurant, and spa. This will enhance the driving experience because EV consumers can enjoy some down-time and relaxation while waiting for their EV to charge. Overall, development of charging centers can provide business opportunities for the private sector, but the private sector will need help. This requires sustained public sector commitment, especially since EV is still at an early stage in Nepal.

Political Opportunities and Barriers

Nepal has an opportunity to increase energy independence through electric mobility. With a transportation sector dominated by gasoline and diesel vehicles, petrol products will continually need to be imported from India, contributing to the trade deficit of which 35-40% is petrol. In place of petrol products, Nepal can harness its hydropower potential. Currently, only about 2,000MW of hydroelectricity is generated, but within a few years multiple hydropower projects will be complete. Thus, there will be stable electricity for sourcing EVs. Furthermore, EVs are beneficial to hydroelectricity because charging can take in surplus electricity. By linking EV and hydropower development, Nepal can increase energy security by reducing reliance on other countries, particularly India, for energy imports. As a small, land-locked country, opportunities for increasing independence is significant, especially when it has to do with securing energy, which is critical for social, economic, and environmental development.

Conclusion

EV development in Kathmandu can be summarized by the failure to appeal to a wider demographic and lack critical infrastructure for mass public participation. Unfortunately, this failure is exceptionally abhorrent given the severity of Nepal's air pollution, as well as inaction to advance electric technologies given stable electricity through renewables, like hydropower. Specifically, the transportation sector plays a large role in greenhouse gas emissions and energy consumption. For instance, if current trends continue in Nepal, GHG emissions will increase two-fold by 2030 and five-fold by 2050, with the transport sector nearly doubling its GHG share by 2050 (from 2005 levels).⁵⁰

After studying EV research thus far, I believe there is justification and potential for Nepal to adopt electric mobility. Opportunities are found in the political and economic interest of energy independence. However, there are major technological barriers to overcome, primarily infrastructure. Additionally, misconceptions and unaffordability of EVs inhibit mass public participation and slow EV market penetration. That being said, consumers are not to blame. The factors limiting EV uptake can largely be improved by stronger commitment from the public and private sectors.

Overall, transitioning to cleaner energy systems is no longer optional but mandatory. Faced with the need for increasingly drastic climate change mitigation/adaptation plans, avoidance of electric mobility shifts from mere impracticality to ignorant passivity. Inspiration for electric transportation in Nepal hits close to home, exceptionally demonstrated by China. However, for widespread EV adoption and diffusion, further research and development is necessary. As such, this paper contributes to these efforts. Regarding the future of EV, I believe it is still at an early stage. As EV technology advances, EV an transition will happen more

organically through improved performance, particularly with higher battery storage and efficient charging. Additionally, as technology and competition progresses, lowering costs will raise consumer demand and bring deeper market penetration. Therefore, further research into both EV technology and consumer behavior should unearth effective combinations of innovation and market diffusion. These dynamics can be further applied to other technologies, which is valuable in today's challenge of securing both economic growth and environmental preservation.

Appendix

Glossary of Terms

AQI Air Quality Index
EV electric Vehicle
GHG greenhouse gas
HEV hybrid electric vehicle
ICE internal combustion engine
kW kilowatt
LIB lithium-ion battery
MW megawatt
NAP *National Action Plan*
NDP Nationally Determined Contribution
PM particulate matter
Rs. Nepalese rupee

List of Interviews

Kathmandu; November 24, 2019
Rajan Rayamajhi, Future Green Energy

Kathmandu; November 25, 2019
Bhusan Raj Bajracharya, Hyundai Kathmandu Pvt. Ltd.

Kathmandu; November 26, 2019
Rupak, NIU Eco Infinity Pvt. Ltd

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